



Specificity of ACL reconstruction in Women ?

Dr Aida ORCE & Dr Nicolas GRAVELEAU, *Bordeaux-Mérignac*



Epidemiology

Review > Orthop J Sports Med. 2021 Dec 17;9(12):23259671211025304.
doi: 10.1177/23259671211025304. eCollection 2021 Dec.

Sexual Dimorphisms in Anterior Cruciate Ligament Injury: A Current Concepts Review

Tayt M Ellison¹, Ilexa Flagstaff², Anthony E Johnson³

120 000 ACL injuries/annually



17

Ratio { 2:1
9:1



Female Soccer Players With Anterior Cruciate Ligament Reconstruction Have a Higher Risk of New Knee Injuries and Quit Soccer to a Higher Degree Than Knee-Healthy Controls

Anne Fältström,^{†††} RPT, PhD, Joanna Kvist,^{††} RPT, PhD, Håkan Gauffin,^{||} MD, PhD, and Martin Häggglund,^{††} RPT, PhD
Investigation performed at the Division of Physiotherapy, Department of Medical and Health Sciences, Linköping University, Linköping, Sweden

EPIDEMIOLOGY related to sport

- Basket
 - 0,29 LCA/1000 hours of exposure in women
 - 0,08 LCA/1000 expositions chez les garçons

sex-ratio : 3,6
- Soccer
 - 0,32 LCA/1000 hours of exposure in women
 - 0,12 LCA/1000 expositions chez les garçons

sex-ratio 2,77
- Fighting
 - 0,77 LCA/1000 hours of exposure in women
 - 0,19 LCA/1000 hours of exposure in men

sex-ratio 4,05
- Handball:
 - **0.82** LCA rupture /1000 hours of exposure in women
 - 0.31 LCA rupture /1000 hours of exposure in men

Sex-ratio 2,6



Risk factors



- Differentes hypothesis :
 - **Anatomical** hypothesis
 - **Neuromuscular** and **biomechanical** inbalance / disorders
 - Women : **hormonal variations** during menstrual phase
- Extrinsec & intrinsec factors





Risk factors Hormonal effect

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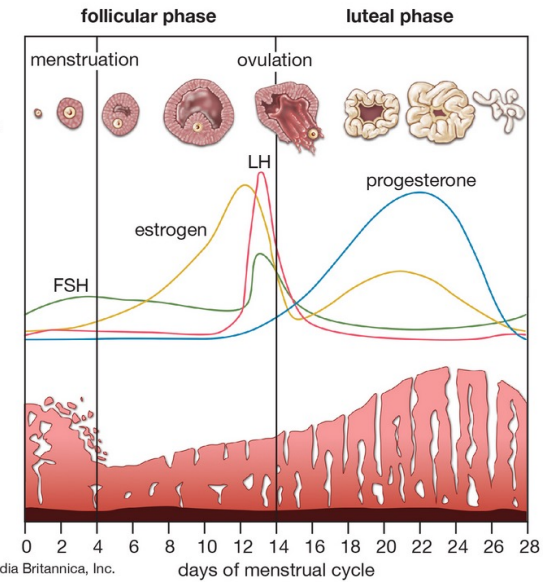
Sexual Dimorphisms in Anterior Cruciate Ligament Injury: A Current Concepts Review

Tayt M Ellison ¹, Ilexa Flagstaff ², Anthony E Johnson ³

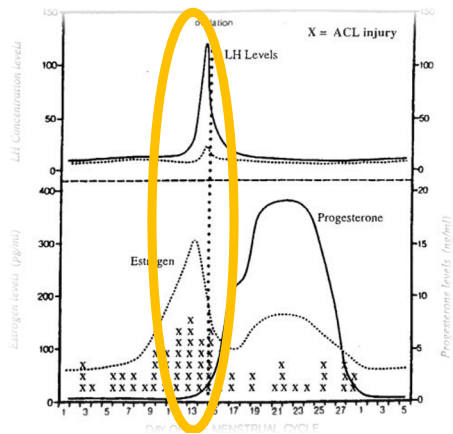
TABLE 2
Literature Support for Menstrual Cycle Phase Effect on ACL Injury^a

	Follicular Phase	Ovulatory Phase	Luteal Phase
Increased risk of ACL injury	Arendt et al ⁹ Arendt et al ¹⁰ Myklebust et al ⁸⁰ (early follicular) Slauterbeck and Hardy ⁹⁸	Wojtyls et al ¹¹⁶ Wojtyls et al ¹¹⁷	Myklebust et al ⁸⁰ (late luteal)
Increased ACL laxity	—	Park et al ⁸³	Deie et al ²⁶ Heitz et al ⁴³ Shultz et al ⁸⁶
Increased strength and fatigue, decreased relaxation	—	Sarwar et al ⁹²	—

^aACL, anterior cruciate ligament. Dashes indicate no data reports/none reported.



↑ Estrogen ↓ ACL strength
↑ pre-ovulatory menstrual phase



Higher ACL tears risks between entre 9th 14th day / 28
Less ACL injury during post ovulatory phase 15th 28th

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TABLE 3
Literature Support for Genetic Role in the Sex-Based Disparity in ACL Injuries^a

Study	Gene	Effect
Johnson et al ⁵⁵	<i>WISP2</i> (Wnt-1-inducible signaling-pathway protein-2) <i>FMOD</i> (fibromodulin) <i>ACAN</i> (aggrecan)	<i>WISP2</i> : decreased expression in female patients with ACL injury <i>FMOD</i> , <i>ACAN</i> : increased expression in female patients with ACL injury
Posthumus et al ⁸⁶	<i>COL5A1</i> / <i>COL12A1</i> (collagen5a1/collagen12a1)	Increased expression in female patients with ACL injury
Rahim et al ⁸⁸	<i>KDR</i> (kinase insert domain receptor)	Protective in female patients against ACL injury

^aACL, anterior cruciate ligament.

Risk factors Genetics



COL5A1/COL12A1



WISP2

> [Scand J Med Sci Sports](#). 2012 Aug;22(4):523-33. doi: 10.1111/j.1600-0838.2010.01270.x. Epub 2011 Mar 16.

Matrix metalloproteinase genes on chromosome 11q22 and the risk of anterior cruciate ligament (ACL) rupture

M Posthumus¹, M Collins, L van der Merwe, D O'Cuinneagain, W van der Merwe, W J Ribbans, M P Schwellnus, S M Raleigh

Review > [Orthop J Sports Med](#). 2021 Dec 17;9(12):23259671211025304. doi: 10.1177/23259671211025304. eCollection 2021 Dec.

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Tayt M Ellison¹, Ilexa Flagstaff², Anthony E Johnson³

> [J Bone Joint Surg Am](#). 2015 Jan 7;97(1):71-9. doi: 10.2106/JBJS.N.00246.

Gene expression differences between ruptured anterior cruciate ligaments in young male and female subjects

Jeffrey S Johnson¹, Melanie A Morscher², Kerwyn C Jones², Susan M Moen¹, Christopher J Klonk², Robin Jacquet³, William J Landis³

ANATOMIC FACTORS

Hyperlaxity

- Numerous studies demonstrate hyperlaxity in young female adolescent > young male adolescent

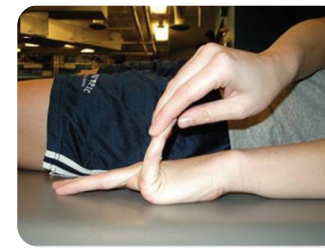
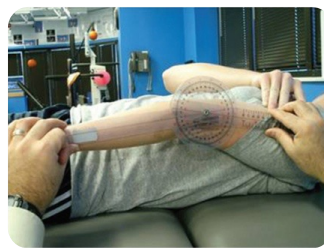
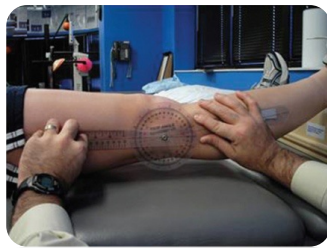
Huston LJ, Wojtys EM. Neuromuscular performance characteristics in elite female athletes. Am J Sports Med. 1996;24:427-436.

Rozzi SL, Lephart SM, Gear WS, Fu FH. Knee joint laxity and neuromuscular characteristics of male and female soccer and basketball players. Am J Sports Med. 1999;27:319.

Shultz SJ, Shimokochi Y, Nguyen AD, et al. Measurement of varusvalgus and internal-external rotational knee laxities in vivo. Part II: relationship with anterior-posterior and general joint laxity in males and females. J Orthop Res. 2007;25:981-988.

- **Ramesh** : ACL tears are more frequent in patient with **GLOBAL JOINT HYPERLAXITY**, especially of the knee

Ramesh R, Von Arx O, Azzopardi T, Schranz PJ. The risk of anterior cruciate ligament rupture with generalized joint laxity. J Bone Joint Surg Br. 2005;87:800-803.



Risk factors Anatomic differences

TABLE 5
Literature in Favor of Other Anatomic Variables
as Contributing Factors in the Sex-Based Disparity
in ACL Injuries^a

Anatomic Variable	Study
Q angle	Zelisko et al ¹²¹
Thigh length	Beynnon et al ¹⁶
ACL tensile properties	Chandrashekar et al, ²³ Johnson et al ⁵⁵
Notch size/ACL size mismatch	Chandrashekar et al, ²³ Stijak et al ¹⁰²
Femoral notch ridge size	Whitney et al ¹¹⁵
Meniscal slope	Meister et al ⁷⁵

^aACL, anterior cruciate ligament.

TABLE 4
Literature in Favor of or Against Specific Anatomic Differences as Contributing Factors
to Sex-Based Disparity in ACL Injuries^a

Posterior Tibial Slope		Notch Width		ACL Volume/Cross-sectional Area	
In Favor	Against	In Favor	Against	In Favor	Against
Beynnon et al ¹⁷	Meister et al ⁷⁵	Anderson et al ⁶	Anderson et al ⁵	Anderson et al ⁵	None
Beynnon et al ¹⁶		Domzalski et al ³⁰	Arendt and Dick ⁸	Chandrashekar et al ²³	
Hashemi et al ⁴²		Emerson ³²	Brandon et al ²⁰	Dienst et al ²⁸	
Hashemi et al ⁴¹		Everhart et al ³³	Chandrashekar et al ²³	Lipps et al ⁶⁵	
Lipps et al ⁶⁵		Hoteya et al ⁴⁷	Van Eck et al ¹¹¹	Stijak et al ¹⁰²	
Markolf et al ⁷¹		Lund-Hanssen et al ⁶⁸	Hewett et al ⁴⁵	Whitney et al ¹¹⁵	
Simon et al ⁹⁷		Shelbourne et al ⁹⁴	Hutchinson and Ireland ⁵¹		
Sturnick et al ¹⁰³		Simon et al ⁹⁷	Ireland et al ⁵³		
Todd et al ¹⁰⁸		Souryal and Freeman ⁹⁹	LaPrade and Burnett ⁵⁹		
		Sturnick et al ¹⁰³	Lombardo et al ⁶⁷		
		Uhorchak et al ¹¹⁰	Schickendantz and Weiker ⁹³		
		Van Eck et al ¹¹²	Teitz et al ¹⁰⁶		
		Whitney et al ¹¹⁵			
	Wolters et al ¹¹⁹				
	Zeng et al ¹²²				

^aACL, anterior cruciate ligament.

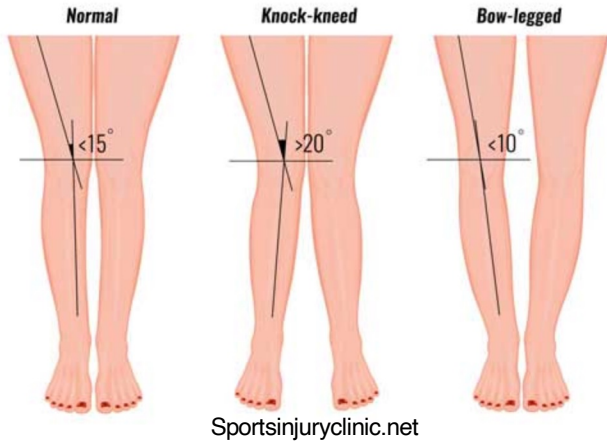
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Q Angle of the Knee



Risk factors Anatomical differences

PLoS One, 2019; 14(6): e0218387.
Published online 2019 Jun 13. doi: [10.1371/journal.pone.0218387](https://doi.org/10.1371/journal.pone.0218387)

PMCID: PMC6564690
PMID: [31194851](https://pubmed.ncbi.nlm.nih.gov/31194851/)

Measurement of the quadriceps (Q) angle with respect to various body parameters in young Arab population

Ramada R. Khasawneh, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Supervision, Writing – original draft, Writing – review & editing,^{1,*} Mohammed Z. Allouh, Conceptualization,^{#2} and Ejial Abu-El-Rub, Formal analysis^{#3}

Quadriceps angle

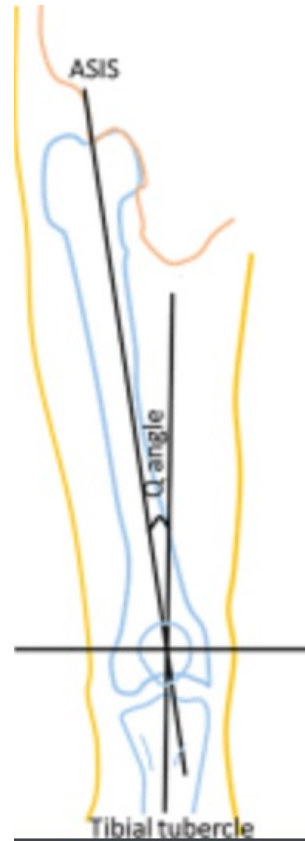


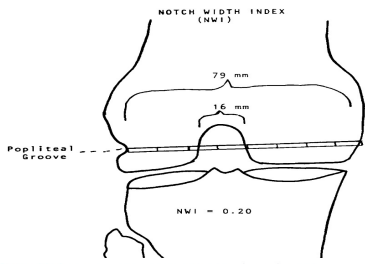
3.4° to 4.9°

Review > [J Am Acad Orthop Surg](https://doi.org/10.5435/JAAOS-21-01-41). 2013 Jan;21(1):41-50. doi: [10.5435/JAAOS-21-01-41](https://doi.org/10.5435/JAAOS-21-01-41).

Anterior cruciate ligament rupture: differences between males and females

Karen M Sutton¹, James Montgomery Bullock





> *Am J Sports Med.* Mar-Apr 1994;22(2):198-202; discussion 203. doi: 10.1177/036354659402200208.

Femoral intercondylar notch stenosis and correlation to anterior cruciate ligament injuries. A prospective study

R F LaPrade¹, Q M Burnett 2nd

> *Knee Surg Sports Traumatol Arthrosc.* 2001 Jul;9(4):200-5. doi: 10.1007/s001670100197.

A radiographic analysis of the relationship between the size and shape of the intercondylar notch and anterior cruciate ligament injury

M L Ireland¹, B T Ballantyne, K Little, I S McClay

> *Am J Sports Med.* 2015 Apr;43(4):839-47. doi: 10.1177/0363546514563277. Epub 2015 Jan 12.

Combined anatomic factors predicting risk of anterior cruciate ligament injury for males and females

Daniel R Sturnick¹, Pamela M Vacek², Michael J DeSarno², Mack G Gardner-Morse¹, Timothy W Tourville¹, James R Slauterbeck¹, Robert J Johnson¹, Sandra J Shultz³, Bruce D Beynon⁴

> *Int J Sports Phys Ther.* 2018 Aug;13(4):575-587.

RISK FACTORS ASSOCIATED WITH NON-CONTACT ANTERIOR CRUCIATE LIGAMENT INJURY: A SYSTEMATIC REVIEW

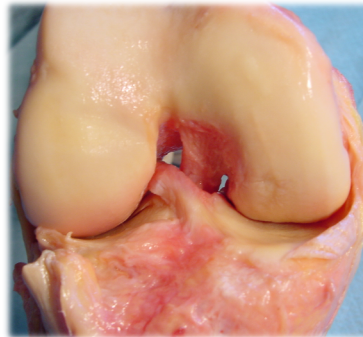
Craig E Pfeifer¹, Paul F Beattie², Ryan S Sacko³, Amy Hand²

Risk factors

Anatomical differences

Intercondylar notch

“A” shaped notch / Narrow notch



Decrease in ICN width: higher risk in women

> *Knee Surg Sports Traumatol Arthrosc.* 2018 Apr;26(4):1252-1257. doi: 10.1007/s00167-017-4625-4. Epub 2017 Jun 23.

Stenotic intercondylar notch type is correlated with anterior cruciate ligament injury in female patients using magnetic resonance imaging

Theodoros Bouras¹, Peter Fennema², Stephen Burke³, Hilary Bosman⁴

Review > *J Am Acad Orthop Surg.* 2013 Jan;21(1):41-50. doi: 10.5435/JAAOS-21-01-41.

Anterior cruciate ligament rupture: differences between males and females

Karen M Sutton¹, James Montgomery Bullock

Figure 1



A

B

C

Arthroscopic images of right knees demonstrating different notch shapes. **A**, A-shaped notch, which narrows from the base through the midsection to the apex. **B**, U-shaped notch, with no tapering from the base to the midsection. **C**, W-shaped notch, with characteristics of a U-shaped notch but with two apparent apices rather than a classic flat roof. (Reproduced with permission from van Eck CF, Martins CA, Vyas SM, Celentano U, van Dijk CN, Fu FH: Femoral intercondylar notch shape and dimensions in ACL-injured patients. *Knee Surg Sports Traumatol Arthrosc* 2010;18[9]:1257-1262.)

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Beynon et al ¹⁶		Domzalski et al ³⁰	Arendt and Dick ⁸	Chandrasekhar et al ²³	
Hashemi et al ⁴²		Emerson ²²	Brandon et al ²⁰	Dienst et al ²⁸	
Hashemi et al ⁴¹		Everhart et al ³³	Chandrasekhar et al ²³	Lipps et al ⁶⁵	
Lippe et al ⁶⁵		Hoteya et al ⁴⁷	Van Eck et al ¹¹	Stijak et al ⁶²	
Markolf et al ⁷¹		Lund-Hanssen et al ⁹⁸	Hewett et al ¹³	Whitney et al ¹¹⁵	
Simon et al ⁹⁷		Shelbourne et al ⁹⁴	Hutchinson and Ireland ⁵¹		
Sturnick et al ¹⁰³		Simon et al ⁹⁷	Ireland et al ⁵³		
Todd et al ¹⁰⁸		Souryal and Freeman ⁹⁹	LaPrade and Burnett ⁹⁹		
		Sturnick et al ¹⁰³	Lombardo et al ⁶⁷		
		Uhrochak et al ¹¹⁰	Schickendantz and Weiker ⁹⁵		
		Van Eck et al ¹¹	Teitz et al ¹⁰⁶		
		Whitney et al ¹¹⁵			
		Walters et al ¹⁹			
		Zeng et al ¹²²			

^aACL, anterior cruciate ligament.

Review | > Orthop J Sports Med. 2021 Dec 17;9(12):23259671211025304.
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Sexual Dimorphisms in Anterior Cruciate Ligament Injury: A Current Concepts Review

Tabt M Ellison¹, Illexa Flagstaff², Anthony E Johnson³

> Am J Sports Med. 2014 May;42(5):1039-48. doi: 10.1177/0363546514523721. Epub 2014 Mar 3.

Increased slope of the lateral tibial plateau subchondral bone is associated with greater risk of noncontact ACL injury in females but not in males: a prospective cohort study with a nested, matched case-control analysis

Bruce D Beynon¹, John S Hall, Daniel R Sturnick, Mike J Desarno, Mack Gardner-Morse, Timothy W Tourville, Helen C Smith, James R Slaughterbeck, Sandra J Shultz, Robert J Johnson, Pamela M Vacek

Review | > J Am Acad Orthop Surg. 2013 Jan;21(1):41-50. doi: 10.5435/JAAOS-21-01-41.

Anterior cruciate ligament rupture: differences between males and females

Karen M Sutton¹, James Montgomery Bullock

Females with an increased lateral slope are 1.2 times as likely to sustain injury

> Int J Sports Phys Ther. 2018 Aug;13(4):575-587.

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Craig E Pfeifer¹, Paul F Beattie², Ryan S Sacko³, Amy Hand²

> Knee Surg Sports Traumatol Arthrosc. 2011 Dec;19 Suppl 1:S109-14. doi: 10.1007/s00167-011-1547-4. Epub 2011 May 24.

Is there a correlation between posterior tibial slope and non-contact anterior cruciate ligament injuries?

Erik Hohmann¹, Adam Bryant, Peter Reaburn, Kevin Tetsworth

> Am J Sports Med. 2019 Jul;47(8):1825-1830. doi: 10.1177/0363546519848424. Epub 2019 May 24.

Lateral Posterior Tibial Slope in Male and Female Athletes Sustaining Contact Versus Noncontact Anterior Cruciate Ligament Tears: A Prospective Study

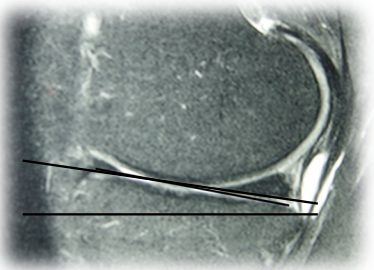
Nicholas N DePhillipo^{1,2}, Connor G Zeigler¹, Travis J Dekker¹, W Jeffrey Grantham¹, Zachary S Aman³, Mitchell I Kennedy³, Robert F LaPrade¹

No difference in sex

> J Orthop. 2020 Sep 11;21:487-490. doi: 10.1016/j.jor.2020.08.032. eCollection Sep-Oct 2020.

Study of relationship of posterior tibial slope in anterior cruciate ligament injury

Tapas Kumar Panigrahi¹, Amit Das¹, Tanmoy Mohanty¹, Swarnendu Samanta², Suwendu Kumar Mohapatra³



Posterior tibial slope

Increased posterior tibial slope contribute to non-contact ACL injuries in females.

Risk factors

Neuromuscular and kinematic control

- 70 à 80% ACL tears mechanisms are **non-contact** pivot sports .
- Situation:
 - landing
 - Change of direction
 - deceleration.



Olsen : static **valgus alignment** of the lower extremity + external/internal rotation is a frequent cause of ACL injuries

Olsen OE, Myklebust G, Engebretsen L, et al. Injury mechanisms for anterior cruciate ligament injuries in team handball: a systematic video analysis. Am J Sports Med 2004;32:1002–12.

Risk factors

Neuromuscular and kinematic control

Comparative Study > Clin J Sport Med. 2009 Jan;19(1):3-8.
doi: 10.1097/JSM.0b013e318190bddd.

The relationship of hamstrings and quadriceps strength to anterior cruciate ligament injury in female athletes

Gregory D Myer¹, Kevin R Ford, Kim D Barber Foss, Chunyan Liu, Todd G Nick, Timothy E Hewett

> Med Sci Sports Exerc. 2004 Jun;36(6):926-34. doi: 10.1249/01.mss.0000128145.75199.c3.

Core stability measures as risk factors for lower extremity injury in athletes

Darin T Leetun¹, Mary Lloyd Ireland, John D Willson, Bryon T Ballantyne, Irene McClay Davis

↑ **Quadriceps / Hamstring ratio**
Quad dominant, less recruitment of hamstrings

↑ **Knee abduction moment**



> Int J Sports Phys Ther. 2018 Aug;13(4):575-587.

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Craig E Pfeifer¹, Paul F Beattie², Ryan S Sacko³, Amy Hand²

> Am J Sports Med. 2005 Apr;33(4):492-501. doi: 10.1177/0363546504269591.
Epub 2005 Feb 8.

Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study

Timothy E Hewett¹, Gregory D Myer, Kevin R Ford, Robert S Heidt Jr, Angelo J Colosimo, Scott G McLean, Antonie J van den Bogert, Mark V Paterno, Paul Succop

> J Electromyogr Kinesiol. 2021 Oct;60:102583. doi: 10.1016/j.jelekin.2021.102583.
Epub 2021 Jul 30.

Sex differences in muscle activation patterns associated with anterior cruciate ligament injury during landing and cutting tasks: A systematic review

Reiko Otsuki¹, Michael J Del Bel², Daniel L Benoit³

Figure 3

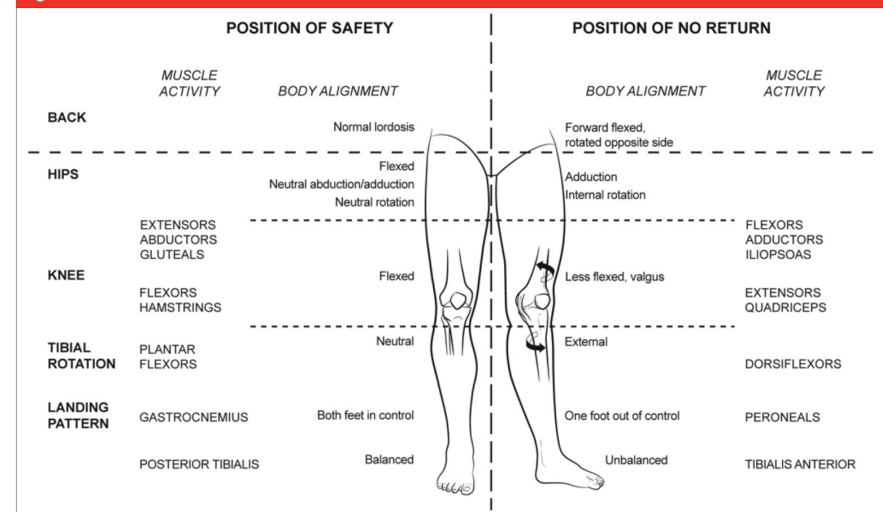


Illustration demonstrating two landing positions: the safe position, with the knee flexed, and the compromised landing position, which is associated with increased risk of anterior cruciate ligament injury in girls and women. (Adapted with permission from Ireland ML: The female ACL: Why is it more prone to injury? *Orthop Clin North Am* 2002;33(4):637-651.)

Review > J Am Acad Orthop Surg. 2013 Jan;21(1):41-50. doi: 10.5435/JAAOS-21-01-41.

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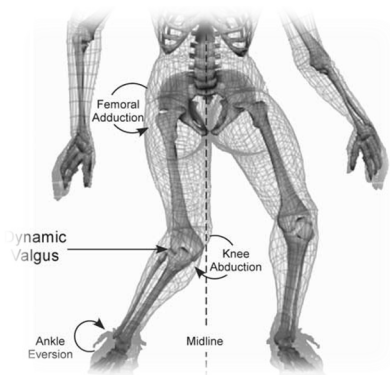
Tayt M Ellison¹, Ilexa Flagstaff², Anthony E Johnson³

Risk factors

Neuromuscular and kinematic control : landing

Hewett : ACL tear risk is correlated with landing in valgus

Athletes should avoid landing with the knee in valgus



Treatment
Few options ...

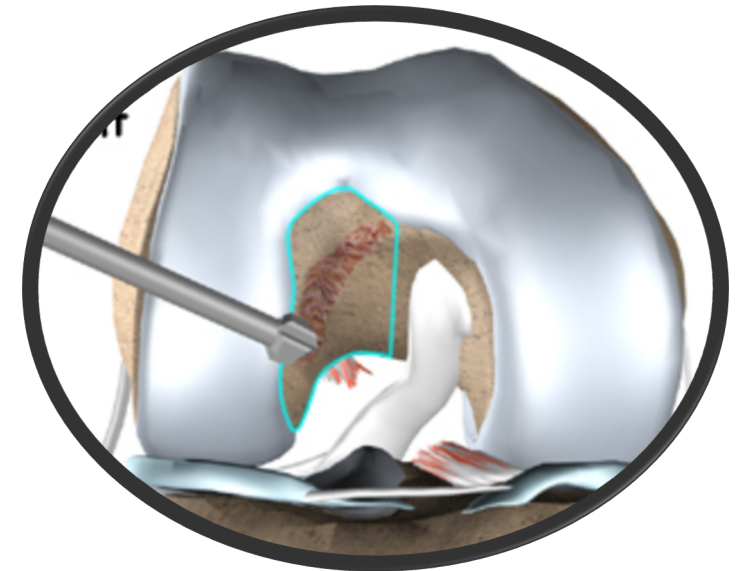
> Orthop J Sports Med. 2021 Sep 8;9(9):23259671211029228. doi: 10.1177/23259671211029228.
eCollection 2021 Sep.

Does Bone Regrow After Notchplasty in ACL Reconstruction? A Prospective Computed Tomography Study With 2-Year Follow-up

Dimitrios Kitridis ^{1 2}, Ioannis Tsifountoudis ³, Dimitrios Georgiannos ¹,
Konstantinos Tsikopoulos ¹, Panagiotis Givissis ², Ilias Bisbinas ¹

Surgery

A- shaped notch Notchplasty ?



If impingement → Notchplasty

Review > J Am Acad Orthop Surg. 2013 Jan;21(1):41-50. doi: 10.5435/JAAOS-21-01-41.

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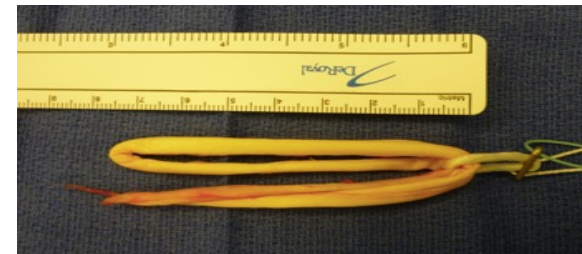
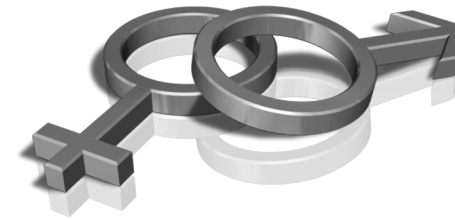
> Knee Surg Sports Traumatol Arthrosc. 2010 Sep;18(9):1257-62.
doi: 10.1007/s00167-010-1135-z.

Femoral intercondylar notch shape and dimensions in ACL-injured patients

Carola F van Eck ¹, Cesar A Q Martins, Shail M Vyas, Umberto Celentano, C Niek van Dijk,
Freddie H Fu

Graft SIZE matter

Minimum graft size ?



Re-rupture rate increase if graft < 8 mm

> [Am J Sports Med.](#) 2012 May;40(5):1161-6. doi: 10.1177/0363546511435627. Epub 2012 Feb 3.

Prediction of the graft size of 4-stranded semitendinosus tendon and 4-stranded gracilis tendon for anterior cruciate ligament reconstruction: a Chinese Han patient study

Guoming Xie ¹, Xiaoqiao Huangfu, Jinzhong Zhao

Adapt the size of the graft to patient size

To small: increased risk of re rupture
« Big » graft diameter : risk of flessum / post pain in flexion

> Orthop J Sports Med. 2020 Jun 23;8(6):2325967120926052. doi: 10.1177/2325967120926052. eCollection 2020 Jun.

The Affect of Patient Sex and Graft Type on Postoperative Functional Outcomes After Primary ACL Reconstruction

Milos Lesevic¹, Michelle E Kew¹, Stephan G Bodkin², David R Diduch¹, Stephen F Brockmeier¹, Mark D Miller¹, F Winston Gwathmey¹, Brian C Werner¹, Joseph M Hart^{1, 2}

Randomized Controlled Trial

> Knee Surg Sports Traumatol Arthrosc. 2021 Sep;29(9):3025-3036. doi: 10.1007/s00167-020-06334-5. Epub 2020 Oct 31.

Autograft type affects muscle strength and hop performance after ACL reconstruction. A randomised controlled trial comparing patellar tendon and hamstring tendon autografts with standard or accelerated rehabilitation

Riccardo Cristiani^{1, 2}, Christina Mikkelsen^{3, 4}, Peter Wange^{3, 5}, Daniel Olsson⁶, Anders Stålmán^{3, 4}, Björn Engström^{3, 4}

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Karen M Sutton¹, James Montgomery Bullock

> Acta Orthop Belg. 2016 Mar;82(1):72-7.

Role of anthropometric data in the prediction of 4-stranded hamstring graft size in anterior cruciate ligament reconstruction

Sean Wei Loong Ho, Teong Jin Lester Tan, Keng Thiam Lee

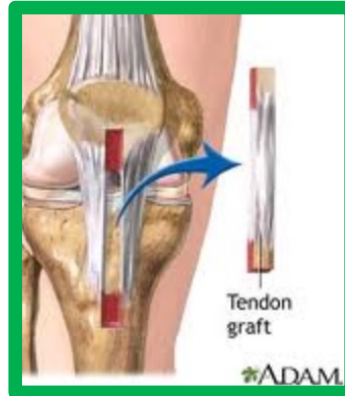
> Am J Sports Med. 2020 Jan;48(1):63-69. doi: 10.1177/0363546519885148. Epub 2019 Nov 15.

Effect of Graft Choice on Revision and Contralateral Anterior Cruciate Ligament Reconstruction: Results From the New Zealand ACL Registry

Richard Rahardja¹, Mark Zhu¹, Hamish Love², Mark G Clatworthy³, Andrew Paul Monk^{1, 4}, Simon W Young^{1, 5}

Surgery Graft selection ?

STIFFNESS



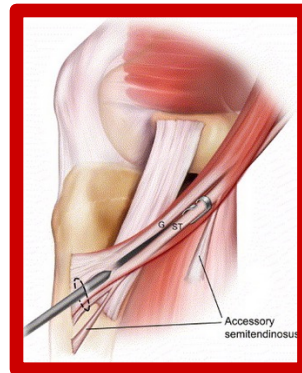
Patellar tendon graft

> Orthop J Sports Med. 2021 Nov 17;9(11):23259671211056325. doi: 10.1177/23259671211056325. eCollection 2021 Nov.

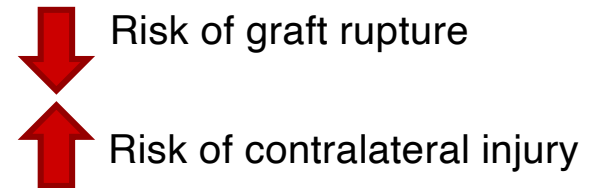
Knee Hyperextension Greater Than 5° Is a Risk Factor for Failure in ACL Reconstruction Using Hamstring Graft

Tales Mollica Guimarães^{1, 2}, Pedro Nogueira Giglio¹, Marcel Faraco Sobrado^{1, 2}, Marcelo Batista Bonadio¹, Ricardo Gomes Gobbi¹, José Ricardo Pécora¹, Camilo Partezani Helito^{1, 2}

Cosmetic but ...



Hamstrings



Surgery

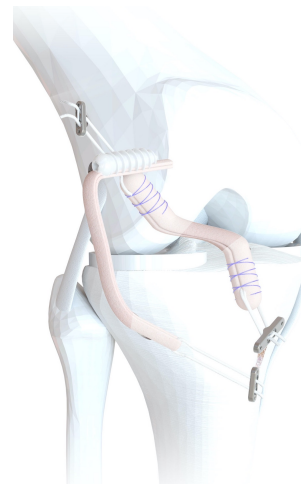
Additional ALL reconstruction ? Lateral tenodesis ?

J Orthopaed Traumatol
DOI 10.1007/s10195-017-0449-8

EMERGING TOPIC (REVIEW ARTICLE)

Anterolateral Ligament Expert Group consensus paper on the management of internal rotation and instability of the anterior cruciate ligament - deficient knee

Bertrand Sonnerly-Cottet¹ · Matthew Daggett² · Jean-Marie Fayard¹ · Andrea Ferretti³ · Camilo Partezani Helio⁴ · Martin Lind⁵ · Edoardo Monaco³ · Vitor Barion Castro de Pádua⁶ · Mathieu Thuam¹ · Adrian Wilson⁷ · Stefano Zaffagnini⁸ · Jacco Zijl⁹ · Steven Claes¹⁰



Long-term Graft Rupture Rates After Combined ACL and Anterolateral Ligament Reconstruction Versus Isolated ACL Reconstruction

A Matched-Pair Analysis From the SANTI Study Group

Bertrand Sonnerly-Cottet,¹ MD, Ibrahim Haidar,¹ MD, Johnny Reyes,¹ Thomas Fradin,¹ MD, Cedric Ngbllo,¹ MD, Thais Dutra Vieira,¹ MD, Benjamin Frechet,¹ MD, Herve Ouanazar,¹ MD, and Adnan Saithna,² MD
Investigation performed at the Centre Orthopedique Santy, Lyon, France

Anatomic and Histological Study of the Anterolateral Aspect of the Knee

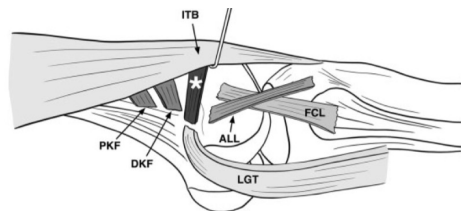
A SANTI Group Investigation

Matt Daggett,¹ DO, Clark Stephenson,¹ MS, John Dobson,¹ MD, Amy Whitaker,¹ BS, Andrea Redler,² MD, Edoardo Monaco,² MD, Barth Wright,¹ PhD, Adnan Saithna,² MD, and Bertrand Sonnerly-Cottet,¹ MD
Investigation performed at Kansas City University, Kansas City, Missouri, USA

Anatomic Study and Reanalysis of the Nomenclature of the Anterolateral Complex of the Knee Focusing on the Distal Iliotibial Band

Identification and Description of the Condylar Strap

Philippe Landreau,¹ MD, Antoine Cattetueuw,² MD, Fawaz Hamie,¹ BS, Adnan Saithna,² MD, Bertrand Sonnerly-Cottet,¹ MD, and Robert Smigielski,¹ MD
Investigation performed at the Sports Surgery Training Center, Aspetar Orthopaedic and Sports Medicine Hospital, Doha, Qatar

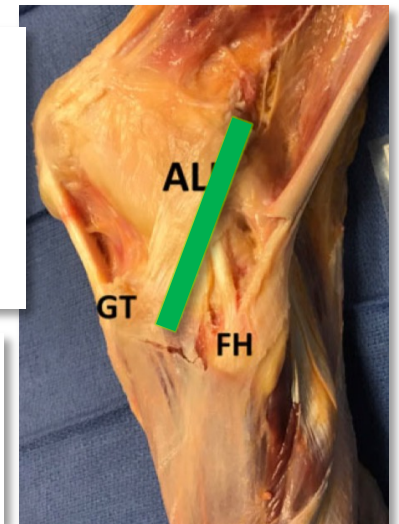


Ahn et al. Knee Surgery & Related Research (2019) 31:12
https://doi.org/10.1186/s43019-019-0012-4

REVIEW ARTICLE Open Access

The anterolateral ligament of the knee joint: a review of the anatomy, biomechanics, and anterolateral ligament surgery

Ji Hyun Ahn¹, Nilay A. Patel², Charles C. Lin³ and Thay Q. Lee⁴



Lateral Extra-articular Tenodesis Has No Effect in Knees With Isolated Anterior Cruciate Ligament Injury

Elmar Herbst, M.D., Fabio V. Arilla, M.D., Daniel Guenther, M.D., Carlos Yacuzzi, M.D., Aia A. Rahnemai-Azar, M.D., Freddie H. Fu, M.D., Richard E. Debski, Ph.D., and Volker Musahl, M.D.

Knee Surg Sports Traumatol Arthrosc
DOI 10.1007/s00167-017-4596-5

KNEE

Clinical outcomes of extra-articular tenodesis/anterolateral reconstruction in the ACL injured knee

Bertrand Sonnerly-Cottet¹ · Nuno Camelo Barbosa¹ · Thais Dutra Vieira¹ · Adnan Saithna^{2,3}

> Am J Sports Med. 2019 Feb;47(2):296-302. doi: 10.1177/0363546518820302. Epub 2019 Jan 14.

Tibial Slope and Its Effect on Force in Anterior Cruciate Ligament Grafts: Anterior Cruciate Ligament Force Increases Linearly as Posterior Tibial Slope Increases

Andrew S Bernhardtson¹, Zachary S Aman², Grant J Dornan², Bryson R Kemler², Hunter W Storaci², Alex W Brady², Gilberto Y Nakama², Robert F LaPrade¹

Surgery

Comparative Study > Am J Sports Med. 2018 Mar;46(3):531-543. doi: 10.1177/0363546517741497. Epub 2017 Dec 15.

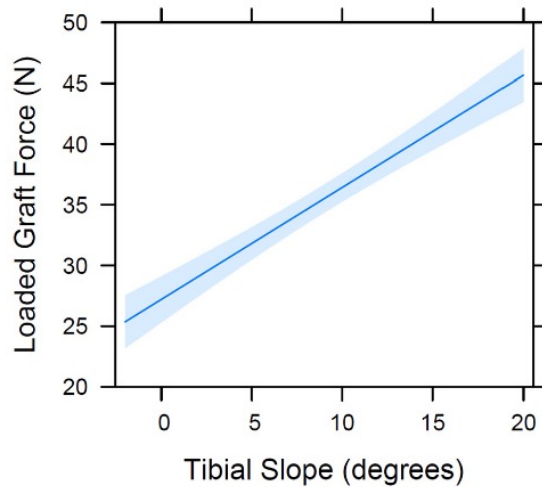
20-Year Outcomes of Anterior Cruciate Ligament Reconstruction With Hamstring Tendon Autograft: The Catastrophic Effect of Age and Posterior Tibial Slope

Lucy J Salmon¹, Emma Heath¹, Hawar Akrawi¹, Justin P Roe¹, James Linklater², Leo A Pinczewski^{1,3}

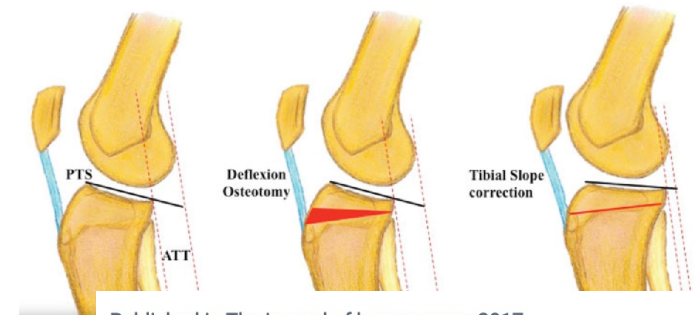
Tibial slope osteotomy ?

>12°

A1 Tibial Slope Effect Plot



Never ?
3rd revision surgery
Revision ACL-R
First intention ?



Published in The journal of knee surgery 2017
Sagittal Plane Corrections around the Knee
D. Dejour, Giuseppe La Barbera, +4 authors M. Saffarini

> Knee Surg Sports Traumatol Arthrosc. 2019 Oct;27(10):3381-3389. doi: 10.1007/s00167-019-05360-2. Epub 2019 Jan 28.

Slope-reducing tibial osteotomy decreases ACL-graft forces and anterior tibial translation under axial load

Florian B Imhoff^{1,2}, Julian Mehl^{1,2}, Brendan J Comer², Elifho Obopilwe², Mark P Cote², Matthias J Feucht¹, James D Wylie^{2,3}, Andreas B Imhoff⁴, Robert A Arciero², Knut Beitzel^{1,2}

Functional outcome

Comparative Study > Am J Sports Med. 2010 Jul;38(7):1334-42.

doi: 10.1177/0363546510361218. Epub 2010 Apr 21.

Sex differences in patient-reported outcomes after anterior cruciate ligament reconstruction: data from the Swedish knee ligament register

Eva Ageberg¹, Magnus Forssblad, Pär Herbertsson, Ewa M Roos

Worst outcome < 2 years PO

Equivalent at >2-year follow-up

Review > Am J Sports Med. 2016 Jan;44(1):242-54. doi: 10.1177/0363546515573008.

Epub 2015 Mar 23.

The Importance of Patient Sex in the Outcomes of Anterior Cruciate Ligament Reconstructions: A Systematic Review and Meta-analysis

Si Heng Sharon Tan¹, Bernard Puang Huh Lau², Lay Wai Khin³, Krishna Lingaraj²

Worst subjective outcomes

Review > Curr Rev Musculoskelet Med. 2021 Dec 31. doi: 10.1007/s12178-021-09736-1.

Online ahead of print.

Disparities in ACL Reconstruction: the Influence of Gender and Race on Incidence, Treatment, and Outcomes

Sai K Devana¹, Carlos Solorzano², Benedict Nwachukwu³, Kristofer J Jones²

Reinjury Rate

x3

Age < 20
Contralateral harvest

> [Am J Sports Med.](#) 2015 Feb;43(2):295-302. doi: 10.1177/0363546514557245. Epub 2014 Nov 10.

Predictors of contralateral anterior cruciate ligament reconstruction: a cohort study of 9061 patients with 5-year follow-up

Daniel Andersnord ¹, Neel Desai ², Haukur Björnsson ², Sofia Gillén ³, Jón Karlsson ², Kristian Samuelsson ²

10,7 % ipsilateral ACL injury;
11,8% contralateral ACL

3,4% reduced risk of ipsilateral ACL compared to males

Meta-Analysis > [Br J Sports Med.](#) 2021 Aug;55(15):873-882.

doi: 10.1136/bjsports-2020-103408. Epub 2021 May 17.

Does sex affect second ACL injury risk? A systematic review with meta-analysis

Akash D Patel ¹, Garrett S Bullock ², Jordan Wrigley ³, Mark V Paterno ^{4 5}, Timothy C Sell ⁶, Justin M Losciale ^{7 8}

> [Am J Sports Med.](#) 2020 Jan;48(1):63-69. doi: 10.1177/0363546519885148. Epub 2019 Nov 15.

Effect of Graft Choice on Revision and Contralateral Anterior Cruciate Ligament Reconstruction: Results From the New Zealand ACL Registry

Richard Rahardja ¹, Mark Zhu ¹, Hamish Love ², Mark G Clatworthy ³, Andrew Paul Monk ^{1 4}, Simon W Young ^{1 5}

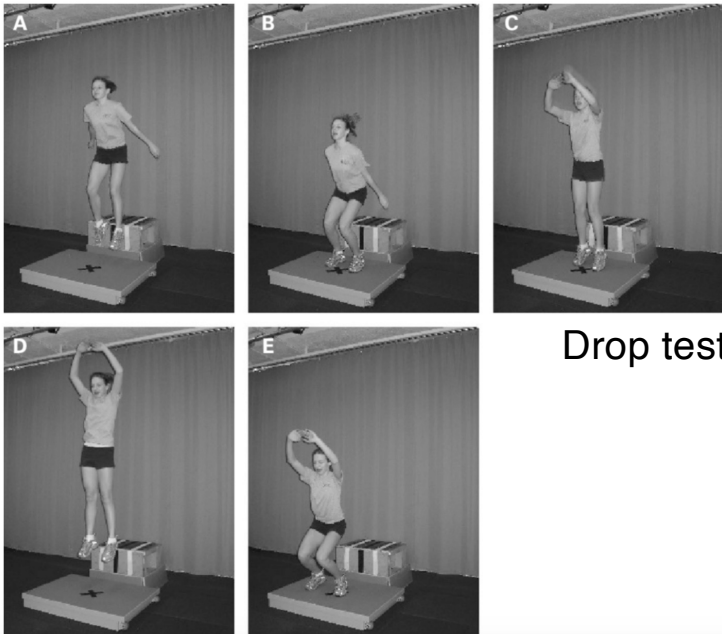
Patellar tendon graft



Risk of graft rupture

Risk of contralateral injury

Prevention



Review > [Br J Sports Med](#). 2008 Jun;42(6):394-412. doi: 10.1136/bjsm.2008.048934.

Non-contact ACL injuries in female athletes: an International Olympic Committee current concepts statement

P Renstrom ¹, A Ljungqvist, E Arendt, B Beynnon, T Fukubayashi, W Garrett, T Georgoulis, T E Hewett, R Johnson, T Krosshaug, B Mandelbaum, L Micheli, G Myklebust, E Roos, H Roos, P Schamasch, S Shultz, S Werner, E Wojtys, L Engebretsen

Table 1

Components of an Ideal Anterior Cruciate Ligament Injury Prevention Protocol

- 10 min, 3 times/wk for approximately 8 wk
- Preseason implementation for neuromuscular adaptation
- Perform as a warm-up to avoid neuromuscular fatigue
- Maintenance recommended to avoid deconditioning, which can occur at 2 to 8 wk
- Must include neuromuscular and proprioceptive training, plyometrics, agility drills, functional balance, and core strengthening
- Low cost and easy to implement
- Identify at-risk players who need more intensive intervention (eg, drop vertical test)
- Encourage compliance (eg, varied workouts, correlate training with improved sport/muscular performance, risk awareness education/training)

Review > [J Am Acad Orthop Surg](#). 2013 Jan;21(1):41-50. doi: 10.5435/JAAOS-21-01-41.

Anterior cruciate ligament rupture: differences between males and females

Karen M Sutton ¹, James Montgomery Bullock

Neuromuscular program and proprioceptive training

Prevention works



Review > Arch Orthop Trauma Surg. 2018 Jan;138(1):51-61.
doi: 10.1007/s00402-017-2809-5. Epub 2017 Oct 5.

Evidence-based concepts for prevention of knee and ACL injuries. 2017 guidelines of the ligament committee of the German Knee Society (DKG)

Julian Mehl¹, Theresa Diermeier¹, Elmar Herbst¹, Andreas B Imhoff¹, Thomas Stoffels², Thore Zantop³, Wolf Petersen⁴, Andrea Achtnich⁵

Review > Clin Sports Med. 2017 Jan;36(1):189-232. doi: 10.1016/j.csm.2016.06.012.

Rehabilitation Principles of the Anterior Cruciate Ligament Reconstructed Knee: Twelve Steps for Successful Progression and Return to Play

Kevin E Wilk¹, Christopher A Arrigo²

Neuromuscular program and proprioceptive training

> Am J Sports Med. 2005 Jul;33(7):1003-10. doi: 10.1177/0363546504272261.
Epub 2005 May 11.

Effectiveness of a neuromuscular and proprioceptive training program in preventing anterior cruciate ligament injuries in female athletes: 2-year follow-up

Bert R Mandelbaum¹, Holly J Silvers, Diane S Watanabe, John F Knarr, Stephen D Thomas, Letha Y Griffin, Donald T Kirkendall, William Garrett Jr

62% risk reduction

Review > J Bone Joint Surg Am. 2012 May 2;94(9):769-76. doi: 10.2106/JBJS.K.00467.

Effectiveness of anterior cruciate ligament injury prevention training programs

Patrick Sadoghi¹, Arvind von Keudell, Patrick Vavken

Meta-Analysis > Am J Sports Med. 2006 Mar;34(3):490-8. doi: 10.1177/0363546505282619.
Epub 2005 Dec 28.

Anterior cruciate ligament injuries in female athletes: Part 2, a meta-analysis of neuromuscular interventions aimed at injury prevention

Timothy E Hewett¹, Kevin R Ford, Gregory D Myer

Conclusion

- Higher ACL injury incidence in women
- Women's ACLs : smaller , less rigid, less resistant on a more lax joint
- **Risk factors:** multifactorial
- **Anatomic factors** may contribute: greater Q angle, smaller ACL size, narrower intercondylar notch, increased POST slope, increase static valgus
- **Neuromuscular and proprioceptive protocols** are vital to reduce injury incidence.
- Further studies are to be performed to have a better understanding
- Probably needs “dedicated” approaches



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